

SECTION 2

Objectives

- ▶ List three characteristics of tropical rain forests.
- ▶ Name and describe the main layers of a tropical rain forest.
- ▶ Describe one plant in a temperate deciduous forest and an adaptation that helps the plant survive.
- ▶ Describe one adaptation that may help an animal survive in the taiga.
- ▶ Name two threats to the world's forest biomes.

Key Terms

tropical rain forest
emergent layer
canopy
epiphyte
understory
temperate rain forest
temperate deciduous forest
taiga

Forest Biomes

The air is hot and heavy with humidity. You walk through the shade of the tropical rain forest, step carefully over tangles of roots and vines, and brush past enormous leaves. Life is all around you, but you see little vegetation on the forest floor. Birds call, and monkeys chatter from far above.

Tropical Rain Forests

Of all the biomes in the world, forest biomes are the most widespread and are home to the greatest diversity of plants, animals, and other organisms. Trees need a lot of water, so forests exist where precipitation is plentiful. Tropical forests, temperate forests, and taiga are the main types of forest biomes.

Tropical rain forests are always humid and warm and get about 200 to 450 cm of rain a year. They help regulate world climate and play vital roles in the nitrogen, oxygen, and carbon cycles. The tropical climate is ideal for a wide variety of plants and animals, as shown in **Figure 2.1**. The warm, wet conditions also nourish more species of plants than does any other biome. While one hectare (10,000 m²) of temperate forest usually contains two dozen species of trees, the same area of tropical rain forest may contain more than 250 species of trees. Tropical rain forests are located in a belt around Earth near the equator, as shown in **Figure 2.2**. Because they are near the equator, tropical rain forests receive strong sunlight and maintain a relatively constant temperature year-round.

FIGURE 2.1

Species Diversity Tropical rain forests contain a larger number of species than any other biome.



Tropical rain forests receive large amounts of precipitation all year long.



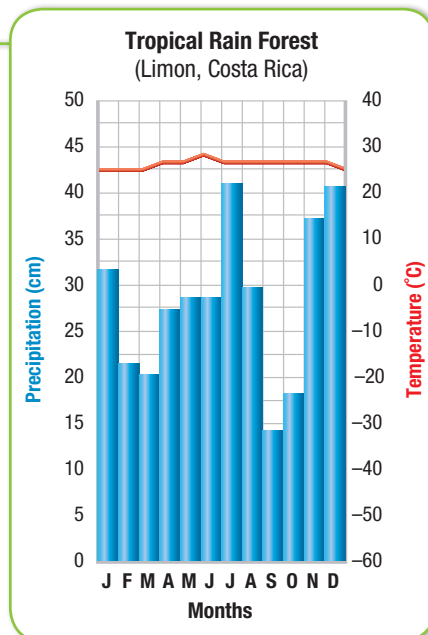
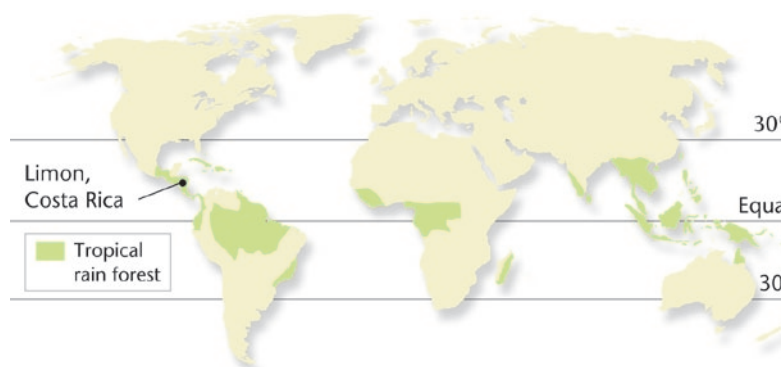
Glasswing butterflies live in the rain forests of Costa Rica.



The *Rafflesia keithii* flower grows in the rain forests of Borneo.

FIGURE 2.2

Tropical Rain Forest The world's tropical rain forests have heavy rainfall during much of the year and fairly constant, high temperatures.



Nutrients in Tropical Rain Forests

You might think that the diverse plant life in a tropical rain forest grows on rich soil, but it does not. Most nutrients are found within the tropical plants, and not within the soil. Organic matter decays quickly in hot, wet conditions. Decomposers on the rain-forest floor break down organic matter and return the nutrients to the soil, but plants quickly absorb the nutrients. Some trees in a tropical rain forest support fungi that feed on dead organic matter on the rain-forest floor. In this relationship, the fungi transfer the nutrients from the dead organic matter directly to the tree.

The nutrients are removed so efficiently from the soil in a tropical rain forest that water running out of the soil may be as clear as distilled water. Many of the trees form above-ground roots, or lateral supports called buttresses, that grow sideways from the trees and provide the trees with extra support in the thin soil.



Red-and-green macaws live in the trees of the Amazon rain forest.



Mountain gorillas live in the rain forests of Rwanda.

FIGURE 2.3

Rain Forest Layers The plants in tropical rain forests form distinct layers. The plants in each layer are adapted to a particular level of light. The taller trees absorb the most light, while the plants near the forest floor are adapted to growing in the shade.



Layers of the Rain Forest

In tropical rain forests, different types of plants grow in different layers, as shown in **Figure 2.3**. The four main layers above the forest floor are the emergent layer, the upper canopy, the lower canopy, and the understory. The top layer is the **emergent layer**. It consists of the tallest trees, which reach heights of 60 to 70 m. Trees in the emergent layer grow above the tops of most other trees in the forest.

The next layer, considered the primary layer of the rain forest, is called the **canopy**. Trees in the canopy can grow more than 30 m tall. The tall trees form a dense layer that absorbs up to 95 percent of the sunlight. The canopy can be split into an upper canopy and a lower canopy. The lower canopy receives less light than does the upper canopy. Plants called **epiphytes**, such as the orchid in **Figure 2.4**, use the entire surface of a tree as a place to live. Epiphytes grow on trees instead of on the ground. Some grow high in the canopy, where their leaves can reach the sunlight needed for photosynthesis. Growing on tall trees also allows them to absorb the water and nutrients that run down the tree after it rains. Most animals that live in the rain forest live in the canopy because they depend on the abundant flowers and fruits that grow there.

Below the canopy, very little light reaches the next layer, called the **understory**. Trees, shrubs, and other plants that are adapted to shade grow here. Most plants in the understory do not grow more than 3.5 m tall. Herbs with large, flat leaves grow on the forest floor. These plants capture the small amount of sunlight that penetrates the understory. Most of our house plants are native to tropical rain-forest floors. Because they are adapted to low levels of light, they are able to grow indoors.

Connect to CHEMISTRY

Medicines from Plants

Many of the medicines we use come from plants native to tropical rain forests. Chemists extract and test chemicals found in plants to determine if the chemicals can cure or fight diseases. Rosy periwinkle, a plant that grows in the tropical rain forests of Madagascar, is the source of two medicines, vinblastine and vincristine. Vinblastine is used to treat Hodgkin's disease, a type of cancer, and vincristine is used to treat childhood leukemia.

Species Diversity in Rain Forests

The tropical rain forest is the biome with the largest number of species. The species diversity of rain forest vegetation has led to the evolution of a diverse community of animals. Most rain-forest animals are specialists that use specific resources in particular ways. Some rain forest animals have amazing adaptations for capturing prey, and other animals have adaptations that they use to escape predators. For example, the giant anteater in **Figure 2.4** uses its long tongue to reach insects in small cracks and holes where other animals cannot reach. The great hornbill (shown below) uses its strong, curved beak to crack open nutshells. Insects, such as the Costa Rican hooded praying mantis in **Figure 2.4**, use camouflage to avoid predators. These insects may be shaped like leaves or twigs.

ECOFACT


A Little Land, A Lot of Species

Tropical rain forests cover less than 7 percent of Earth's land surface but contain at least 50 percent of all the plant and animal species in the world.

FIGURE 2.4

Adaptations Plant and animal adaptations in the tropical rain forest include **1** the long tongue of a giant anteater, **2** the strong, curved beak of a great hornbill, **3** the shape of a Costa Rican hooded praying mantis, and **4** an orchid attached to a tall tree.



 **CHECK FOR UNDERSTANDING**
Identify What are two main threats to the organisms that live in tropical rain forests?

Threats to Rain Forests

Tropical rain forests once covered about 20 percent of Earth's land area. Today, they cover less than 7 percent. Every 60 seconds, nearly 150 acres of tropical rain forest are cleared for logging operations, agriculture, cattle ranching, or oil exploration. *Habitat destruction* occurs when land inhabited by an organism is destroyed or altered. This destruction is the usual reason for a species becoming extinct. Warming temperatures and changes in precipitation from climate change also threaten rain forests.

An estimated 50 million people live in tropical rain forests. These people are also threatened by habitat destruction. Their food, building materials, culture, and traditions come from and are uniquely connected to the rain forest. Habitat loss also destroys their way of life.

Plants and animals that live in rain forests are also threatened by trading. Many plant species found only in tropical rain forests are valuable and marketable to industries. Animals are threatened by exotic-pet trading. Some exotic-pet traders illegally trap animals, such as parrots, and sell them in pet stores at high prices.

CASE STUDY

Deforestation, Climate, and Floods

A plant absorbs water from the soil through its roots and transports the water to its stems and leaves. Water then evaporates from pores in plant leaves into the atmosphere through a process called *transpiration*. A large tree may transpire as much as five tons of water on a hot day. Water absorbs heat when it evaporates. Therefore, the temperature is much cooler under a tree on a hot day than under a wood or brick shelter.

When rain falls on a forest, much of the rain is absorbed by plant roots and transpired into the air as water vapor. Water vapor forms rain clouds. Much of this water will fall as rain downwind from the forest. Because of the role trees play in transpiration, *deforestation*, the clearing of trees, can change the climate. If a forest is cut down or replaced by smaller plants, much of the rainfall is not absorbed by plants. Instead, the rain runs off the soil and causes flooding as well as soil erosion. The climate downwind from the forest becomes drier.

Deforestation led to the disastrous flooding of the Yangtze River in China in 1998. More than 2,000 people died in the floods, and at least 13 million people had to leave their homes. When the Yangtze River



A man makes his way past flooded buildings in his street on a makeshift raft after the Yangtze River reached record-high levels in July 1998.

flooded, the water poured into a flood plain where over 400 million people lived. Serious flooding occurred again in 2010 and 2011. It is estimated that 85 percent of the forest in the Yangtze River basin has been cut down. The millions of tons of water that these trees once absorbed now flow freely down the river and spread across fields and into towns during the seasonal monsoon rains. In response to data from environmental scientists, the Chinese government is now instituting massive reforestation efforts.

Deforestation has also caused major floods in places such as Bangladesh. The Ganges River starts high in the Himalaya Mountains and flows through Bangladesh. Deforestation of the Himalaya Mountains left few trees to stop the water from flowing down the mountain. Therefore, most of the water flows into the river when it rains. Heavy

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Temperate Rain Forests

Temperate rain forest occurs in North America, Australia, and New Zealand. Temperate rain forests have large amounts of precipitation, high humidity, and moderate temperatures. The Pacific Northwest houses North America's only temperate rain forest, shown in **Figure 2.5**. There, tree branches are draped with mosses and tree trunks are covered in lichens. The forest floor is blanketed with lush ferns. Evergreen trees that are 90 m tall, such as the Sitka spruce and the Douglas fir, dominate the forest. Other large trees, such as western hemlock, Pacific silver fir, and redwood, can also be found in temperate rain forests.

Even though some temperate rain forests are located at high latitudes, they still maintain moderate temperatures year-round because nearby ocean waters blow cool ocean wind over the forest. As ocean winds meet coastal mountains, a large amount of rainfall is produced. Rainfall and ocean breezes keep temperatures cool in the summer, but warmer than might be expected in the winter. These wet and warm conditions mean that trees have long growing seasons and plenty of water to grow very tall.

FIGURE 2.5

Pacific Northwest The only temperate rain forest in North America is located in the Pacific Northwest, such as the one shown below in Olympic National Park.



Deforestation reduces the amount of water that is absorbed by plants after it rains. The more trees that are cleared from a forest, the more likely a flood will occur in that area.

rains have eroded and carried away so much soil from the slopes of the mountains that the soil has formed a new island in the Bay of Bengal.

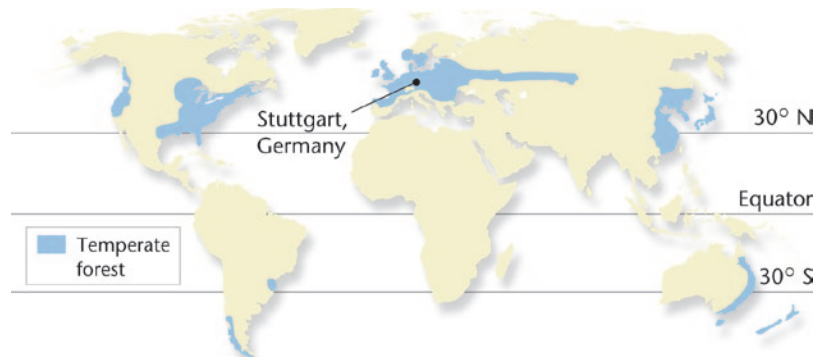
People are beginning to understand the connection between deforestation and floods. People held protests in northern Italy in 2000 after floods covered a town that had never been flooded before. The townspeople claimed that authorities had permitted developers to cover the hills with homes. These developers cut down most of the trees and covered much of the land with asphalt. After heavy rains, the water was no longer absorbed by trees and soil, so the water flowed down the hills and flooded the town.

Critical Thinking

- 1. Identifying Relationships** How might deforestation in China and other countries affect the overall climate of Earth?
- 2. Analyzing a Viewpoint** Imagine that you are a city council member and must vote on whether to clear a forest so that a mall can be built. List the pros and cons of each viewpoint. After reviewing your list, how would you vote? Explain your answer.

FIGURE 2.6

Temperate Deciduous Forest The difference between summer and winter temperatures in temperate deciduous forests is extreme.



Temperate Deciduous Forests

If you walk through a North American deciduous forest in the fall, you will be awash in color. Leaves in every shade of orange, red, and yellow crackle beneath your feet. Most birds have flown south. The forest is quieter than it was in the summer. You see mostly chipmunks and squirrels gathering and storing the food they will need during the long, cold winter.

In **temperate deciduous forests**, trees drop their broad, flat leaves each fall. These forests once dominated vast regions of Earth, including parts of North America, Europe, and Asia. Today, temperate deciduous forests are generally located between 30° and 50° north latitudes, as shown in **Figure 2.6**. The range of temperatures in a temperate deciduous forest can be extreme, and the growing season lasts for only four to six months. Summer temperatures can soar to 35°C. Winter temperatures often fall below freezing, so little water is available for plants and growing seasons tend to be shorter than in the temperate rain forests. Just as temperatures change with the seasons, so does the vegetation, as shown in **Figure 2.7**. Although there is enough moisture for decomposition, temperatures are low during the winter. As a result, organic matter decomposes fairly slowly. This means that the soil contains more organic matter and nutrients than the soil in a tropical rain forest.

FIGURE 2.7

Distinct Seasons The change of seasons in a temperate deciduous forest is shown here.



Plants of Temperate Deciduous Forests

Like the plants of tropical rain forests, the plants in deciduous forests grow in layers. Tall trees, such as maple, oak, and birch, dominate the forest canopy. Small trees and shrubs cover the understory. Because the floor of a deciduous forest gets more light than does the floor of a rain forest, more plants such as ferns, herbs, and mosses grow in a deciduous forest.

Temperate-forest plants are adapted to survive seasonal changes. In the fall, most deciduous trees begin to drop their leaves. In the winter, soil moisture changes to ice, which causes the remaining leaves to fall to the ground.

Herb seeds, bulbs, and rhizomes (underground stems) become dormant in the ground and are insulated by the soil, leaf litter, and snow. In the spring, when the sunlight increases and the temperature rises, trees grow new leaves, seeds germinate, and rhizomes and roots grow new shoots and stems.

Animals of Temperate Deciduous Forests

The animals of temperate deciduous forests are adapted to use the forest plants for food and shelter. Squirrels eat the nuts, seeds, and fruits in the treetops. Bears feast on insects and the tubers and berries of the forest plants. Grasshoppers eat almost all types of vegetation found throughout the forest. Deer, such as the one shown in **Figure 2.8**, and other herbivores nibble leaves from trees and shrubs.

Many birds nest in the relative safety of the canopy. Most of these birds are migratory. Because many birds cannot survive harsh winters, each fall they fly south to find warmer weather and more food. Each spring, they return north to nest and feed. Animals that do not migrate use various strategies for surviving the winter. For example, some mammals reduce their activity during the cold winter months so that they do not need as much food for energy.

FIGURE 2.8

Deciduous Forest Animals Woodpeckers and deer are among the many animals that live in the temperate deciduous forest.



Taiga

The **taiga** is the northern coniferous forest that stretches in a broad band across the Northern Hemisphere just below the Arctic Circle. As shown in **Figure 2.9**, winters in the taiga are long (6 to 10 months) and have average temperatures that are below freezing and often fall to -20°C . Many trees seem like straight, dead shafts of bark and wood—until you look up and see their green tops. Plant growth is most abundant during the summer months because of nearly constant daylight and larger amounts of precipitation.

FIGURE 2.9

Taiga The taiga has long, cold winters and small amounts of precipitation, as shown in the climatogram at right.

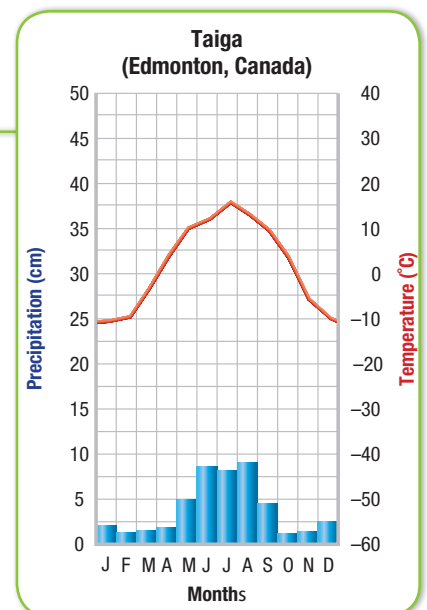
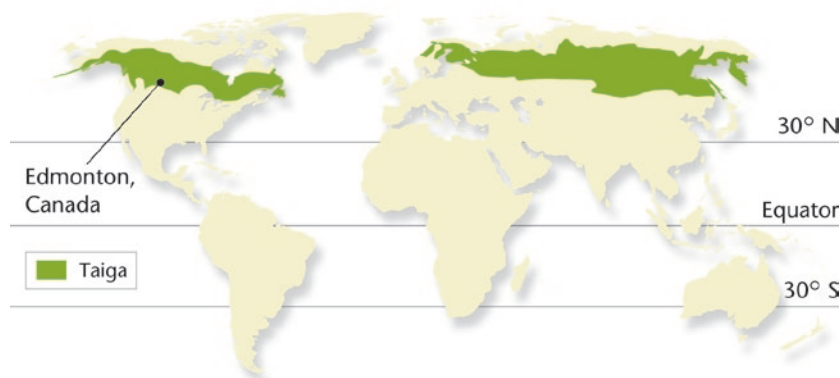


FIGURE 2.10

Taiga Plant Adaptations The seeds of conifers are protected inside tough cones like the one below. Also, the narrow shape and waxy coating of conifer needles help the tree retain water.



Plants of the Taiga

A conifer is a tree with needle-like leaves and seeds that develop in cones. The shape of the leaves and their waxy coating prevent the tree from losing too much water. This is especially important when the ground is frozen and the roots cannot replace lost water by absorbing more from the soil. As **Figure 2.10** shows, many conifers are shaped like a large cone. The cone-like shape helps to prevent snow from building up on the branches and causing the branches to break under the weight.

Conifer needles contain substances that make the soil acidic when the needles fall to the ground. Most plants cannot grow in acidic soil, which is one reason the forest floor of the taiga has few plants. In addition, soil forms slowly in the taiga because the climate and acidity of the fallen needles slow decomposition.

Animals of the Taiga

The taiga has many lakes and swamps that in summer attract birds that feed on aquatic organisms. Many birds migrate south to avoid winter in the taiga. Because food is scarce during the winter, some year-round residents, such as jumping mice, burrow underground to hibernate. As shown in **Figure 2.11**, some animals, such as snowshoe hares, have adapted to reduce the risk of predation by lynxes, wolves, and foxes by shedding their brown summer fur and growing white fur that camouflages them in the winter snow.

FIGURE 2.11

Taiga Animal Adaptations In the taiga, a snowshoe hare's fur changes color according to the seasons to help camouflage the animal from predators.



(t) ©Walter H. Hodges; (inset) ©Stuart Cobley/Alamy Images; (b) ©Paul E. Tessler/Photodisc/Getty Images



Section 2 Formative Assessment

▶ Reviewing Main Ideas

- List** three characteristics of tropical rain forests.
- Name** the main layers of a tropical rain forest. What kinds of plants grow in each layer?
- Describe** two ways in which tropical rain forests of the world are being threatened.
- Describe** how a plant survives the change of seasons in a temperate deciduous forest. Write a short paragraph to explain your answer.

✔ Critical Thinking

- Evaluating Information** Which would be better suited for agricultural development: the soil of a tropical rain forest or the soil of a temperate deciduous forest? Explain your answer.
- Identifying Relationships** How does a snowshoe hare avoid predation by other animals during the winter in a taiga biome? How might this affect the animal that depends on the snowshoe hare for food?